SURFACE WATER

Streams and lakes in the Chippewa River basin contain abundant water of good chemical quality. Man's use of the water has altered slightly streamflow characteristics and quality in some places. About 1,750 billion gallons of surface water leave the basin as streamflow each year. Along its way this water passes through hydroelectric power generating turbines and cooling towers, it receives wastes, and a very small amount is removed for irrigation and other uses. The water also passes through many stages of storage ranging from wetlands and small farm ponds to large reservoirs. At present, surface water is not used for municipal supply because the cost of treatment is high and because ground water is plentiful at most places where surface water is available.

Station no. 5-3565
Chippewa River near Bruce
Drainage area: 1,650 square miles
Period of record: 1913–present
Maximum instantaneous discharge: 25,800 cfs
Average discharge, 52 years: 1,411 cfs
Minimum instantaneous discharge: 155 cfs

Station no. 5-3605
Flambeau River near Bruce
Drainage area: 1,897 square miles
Period of record: 1951–present
Maximum instantaneous discharge: 17,400 cfs
Average discharge, 15 years: 1,727 cfs
Minimum instantaneous discharge: 100 cfs

Station no. 5-3560
Chippewa River at Bishops Bridge, near Winter
Drainage area: 787 square miles
Period of record: 1912–present
Maximum instantaneous discharge: 7,520 cfs
Average discharge, 54 years: 702 cfs
Minimum instantaneous discharge: 14 cfs

Station no. 5-3585
Flambeau River at Babbs Island, near Winter
Drainage area: 1,000 square miles
Period of record: 1929–present
Maximum instantaneous discharge: 9,440 cfs
Average discharge, 37 years: 963 cfs
Minimum instantaneous discharge: 86 cfs

Station no. 5-3674.25
Red Cedar River near Cameron
Drainage area: 450 square miles
Period of record: 1966–present

Station no. 5-3675
Red Cedar River near Colfax
Drainage area: 1,100 square miles
Period of record: 1914–1961
Maximum instantaneous discharge: 21,800 cfs
Average discharge, 47 years: 754 cfs
Minimum instantaneous discharge: 128 cfs

Station no. 5-3680
Hay River at Wheeler
Drainage area: 426 miles
Period of record: 1950–present
Maximum instantaneous discharge: 10,800 cfs
Average discharge, 16 years: 267 cfs
Minimum instantaneous discharge: 55 cfs

Station no. 5-3690
Red Cedar River at Menomonie
Drainage area: 1,760 square miles
Period of record: 1907–1908, 1913–present
Maximum instantaneous discharge: 40,000 cfs
Average discharge, 54 years: 1,193 cfs
Minimum instantaneous discharge: 21 cfs

Station no. 5-3700
Eau Galle River at Spring Valley
Drainage area: 64.8 square miles
Period of record: 1944–present
Maximum instantaneous discharge: 33,000 cfs[1]
Average discharge, 22 years: 25.9 cfs
Minimum instantaneous discharge: 5.8 cfs
[1] 1942, estimated by U.S. Army Corps of Engineers

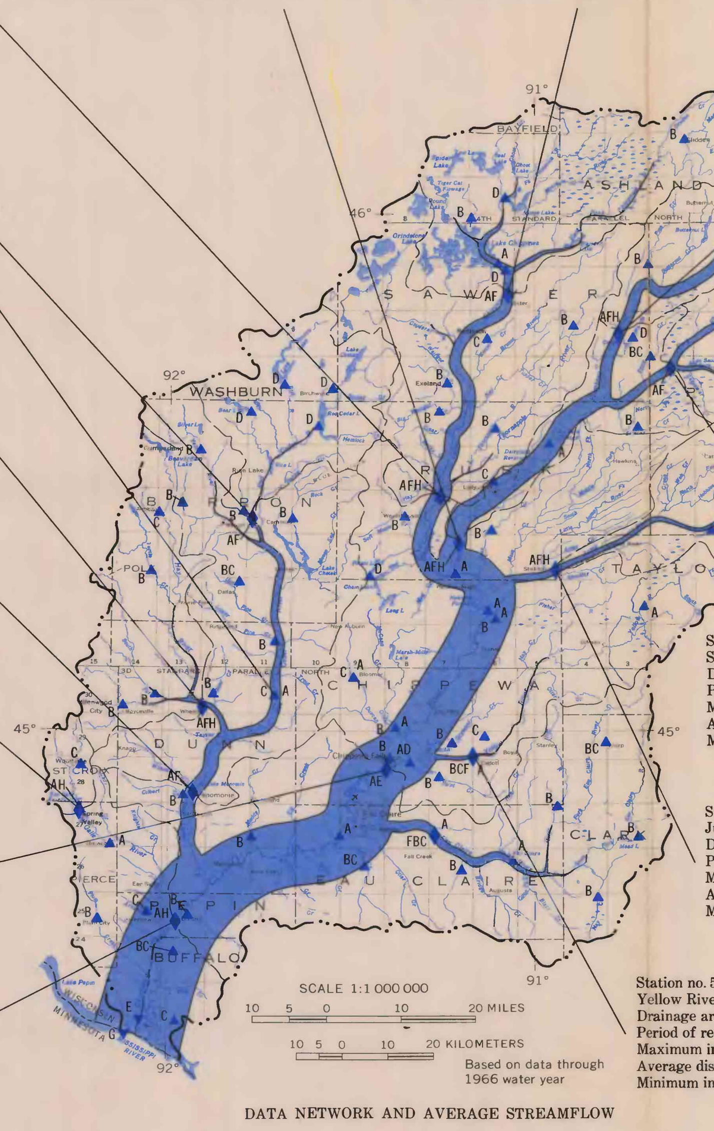
Station no. 5-3655
Chippewa River at Chippewa Falls
Drainage area: 5,600 square miles
Period of record: 1888–present
Maximum instantaneous discharge: 102,000 cfs
Average discharge, 78 years: 5,044 cfs
Minimum instantaneous discharge: 22 cfs

Station no. 5-3695
Chippewa River at Durand
Drainage area: 9,010 square miles
Period of record: 1928–present
Maximum instantaneous discharge: 101,000 cfs
Average discharge, 38 years: 7,222 cfs
Minimum instantaneous discharge: 1,020 cfs

Station no. 5-3595
South Fork Flambeau River near Phillips
Drainage area: 615 square miles
Period of record: 1929–present
Maximum instantaneous discharge: 10,200 cfs
Average discharge, 37 years: 581 cfs
Minimum instantaneous discharge: 39 cfs

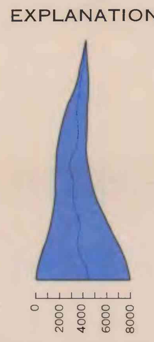
Station no. 5-3620
Jump River at Sheldon
Drainage area: 574 square miles
Period of record: 1915–present
Maximum instantaneous discharge: 46,000 cfs
Average discharge, 51 years: 504 cfs
Minimum instantaneous discharge: 11 cfs

Station no. 5-3640
Yellow River at Cadott
Drainage area: 351 square miles
Period of record: 1942–1961
Maximum instantaneous discharge: 15,600 cfs
Average discharge, 19 years: 273 cfs
Minimum instantaneous discharge: 1.5 cfs



DATA NETWORK AND AVERAGE STREAMFLOW

EXPLANATION



Width of pattern indicates approximate average discharge of stream, in cfs (cubic feet per second). Discharge less than 50 cfs not shown

Measurement site symbol	Parameter measured	Frequency of measurement
A ▲	Stream discharge	Continuous
B ▲	Low-flow stream discharge	Intermittent
C ▲	Flood-flow stream discharge	Periodic
D ▲	Lake stage	Periodic
E ▼	Chemical quality	Monthly[1]
F ▼	Chemical quality	Intermittent
G ▼	Chemical quality	Weekly[2]
H ▼	Sediment	Intermittent

Letter to left indicates present measurement; letter to right indicates discontinued measurement

[1] Operated by the Wisconsin Department of Natural Resources
[2] Operated by the Minneapolis-St. Paul Sanitary District

Boundary of basin above active continuous record station

Surface-water divide

Stream discharge records in the basin date from as early as 1888. Continuous discharge has been monitored during various periods of time at 31 gaging stations in the basin, 12 of which are measured at present. Station data are given for the 12 active stations and for 2 discontinued stations through the 1966 water year (U.S. Geological Survey, 1967). Sites of past and present measurements of lake stage and water quality also are shown on the map.

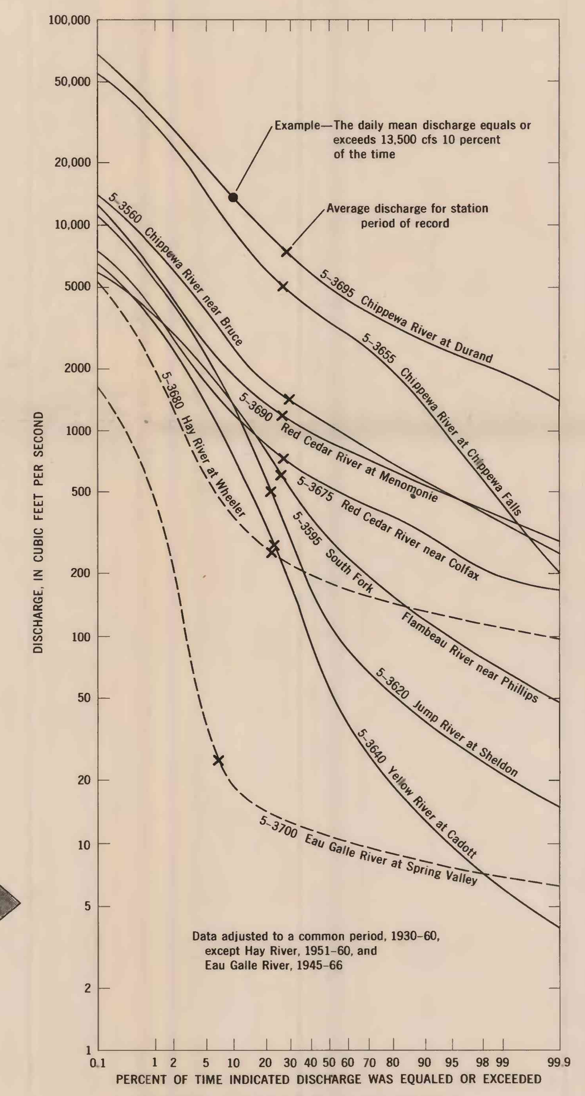
The average discharge diagram gives a visual impression of basin-wide distribution of surface runoff. It is based on the mean of all yearly mean discharges of record and is about 7,430 cfs (cubic feet per second) at the mouth of the river.

Streamflow at all gaging stations in the basin, except those on the Jump, Yellow, Hay, and South Fork Flambeau Rivers, is affected to various degrees by surface storage or regulation for hydroelectric power generation. A flood-control dam was completed late in 1968 by the U.S. Army Corps of Engineers on the previously uncontrolled Eau Galle River at Spring Valley.

The flow-duration curve shows the percentage of time specified discharges were equaled or exceeded during a given period. This curve relates to the hydrologic characteristics of a basin as well as shows the availability of a given streamflow.

The lower part of a duration curve represents the low-flow characteristics of the basin. A flat slope indicates a nearly constant and uniform release of storage, either from surface reservoirs (Red Cedar River at Menomonie and near Colfax, and Chippewa River at Durand and near Bruce) or from ground water (Hay River at Wheeler and Eau Galle River at Spring Valley). A steep slope indicates low storage and a relatively rapid recession of base flow. The Jump and Yellow Rivers, for example, have little ground- or surface-water storage. The steep slope of the lower end of the duration curve of the Chippewa River at Chippewa Falls indicates periodic regulation of surface storage; during summer weekends water is stored to be used for hydroelectric power generation during the week.

The upper end of the flow-duration curve shows the high-flow characteristics of the basin; a steep slope indicates high flows from rainfall and snowmelt. This is true of all the curves shown. The Hay and Eau Galle Rivers, which have the steepest slopes on the upper end, drain areas of steep topography and poor soil infiltration, and produce flashy streamflow.

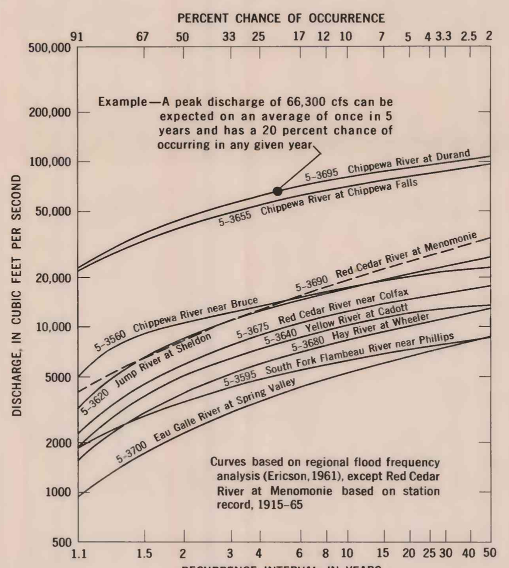


DURATION OF DAILY MEAN DISCHARGE
OF MAJOR RIVERS

FLOODS

Damaging floods have been infrequent in the basin. The three largest recorded floods on the Chippewa River at Chippewa Falls, in decreasing order of magnitude, were in 1884, 1941, and 1880. Eau Claire and Durand are subject to the greatest urban damages. The U.S. Army Corps of Engineers (written communication, 1968) assesses the average annual damages for these cities, respectively, as $102,700 and $19,500. Total average annual damage to agriculture, rural nonagriculture, transportation, and cities was determined as $550,400 from the mouth to Moose Lake (U.S. Army Corps of Engineers, written communication, 1968). Of this total, $377,200 is for the 80-mile reach below Chippewa Falls.

Most floods in the basin are of two types: 1) spring floods (March through May), which are the result of rapid snowmelt and, occasionally, concurrent rainfall, and 2) summer floods (June through September), which are the result of widespread and heavy rainfall of many hours duration. Most annual peaks are due to spring snowmelt, but the major peaks are due to heavy summer rainfall or a combination of snowmelt and heavy spring rainfall.



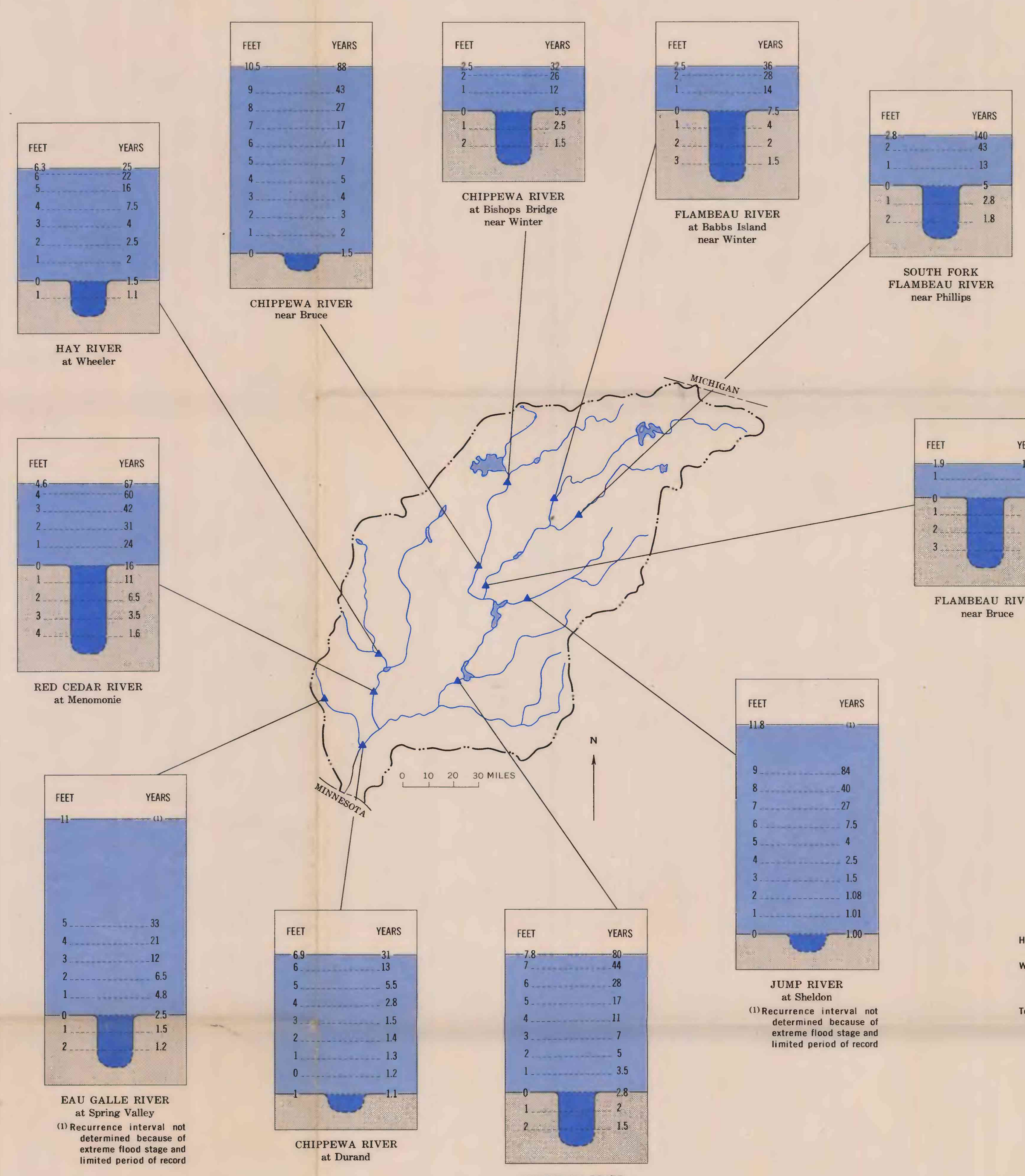
FLOODFLOW RECURRENCE OF MAJOR RIVERS

The flood-frequency curve shows the probable recurrence interval, or percent chance of occurrence, of a discharge of given magnitude. The frequency curves shown are based on a regional analysis of flood data in Wisconsin by Ericson (1961). His report can be used also to estimate flood frequencies for ungaged drainage basins of 20 to 500 square miles. Additional data on flood frequency are available for several gaging stations (K. B. Young, 1963, 1965).

In general, flood magnitude depends on the drainage area and the resultant volume of runoff from precipitation. However, different flood characteristics among basins may be due to differences in rock types, low to moderate soil infiltration capacity, and a lack of swamps, lakes or forest cover for storage of surface runoff. The Yellow and Jump Rivers also have relatively high floodflow because of low permeability soils and few swamps.

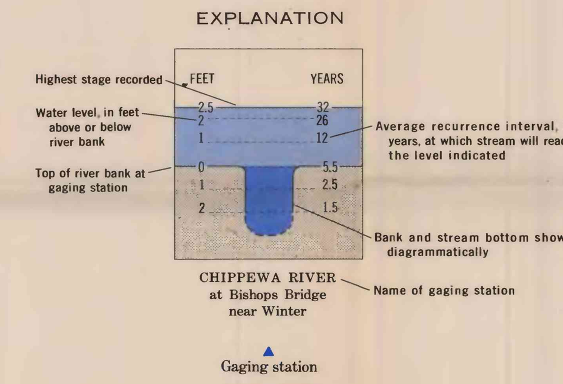
For example, the Eau Galle River has very high flood discharge for its small basin size. This is due to very steep channel and tributary slopes, low to moderate soil infiltration capacity, and a lack of swamps, lakes, or forest cover for storage of surface runoff.

A majority of the rivers represented by the flood-frequency curves have 50-year floods of 13 to 17 cfs per square mile, but range between 13 for the Chippewa at Durand to 135 for the Eau Galle at Spring Valley.



(1) Recurrence interval not determined because of extreme flood stage and limited period of record

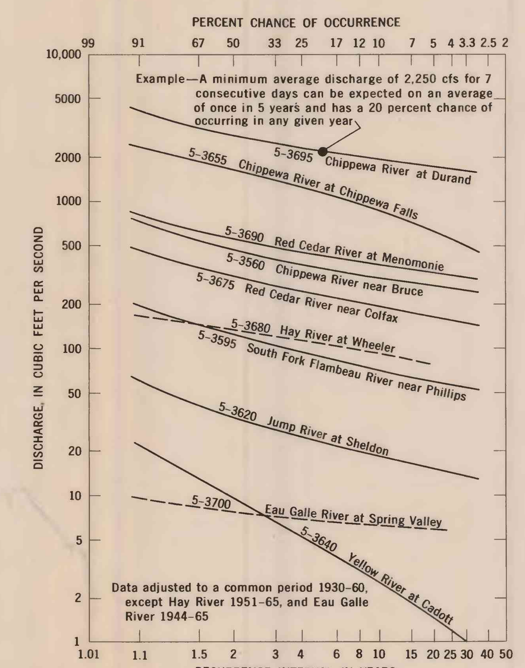
EXPLANATION



FLOOD-STAGE FREQUENCY

The small diagrams show how often, on the average, the streams can be expected to reach a given stage. Flood-stage frequency was determined by relating recorded annual peak flood stages to discharge ratings and flood-frequency relations. Occasional peak stages caused by ice jams or floating debris may have a recurrence interval greater than that of the coincident discharge. Because the controlling factors are different at each site on the stream, these stage diagrams can be used to estimate flood heights only in the vicinity of the gaging stations.

LOW FLOW



7-DAY LOW-FLOW RECURRENCE
OF MAJOR RIVERS

Low flow is expressed commonly as the lowest average discharge during 7 consecutive days in a year. This period minimizes surface runoff from precipitation and abnormally low daily discharges due to flow regulation. The curves give the probable recurrence interval, or percent chance of occurrence, of a 7-day minimum average discharge of given magnitude. Data for 10 additional periods of 1 to 274 days have been computed for several gaging stations (K. B. Young, 1963, 1965).

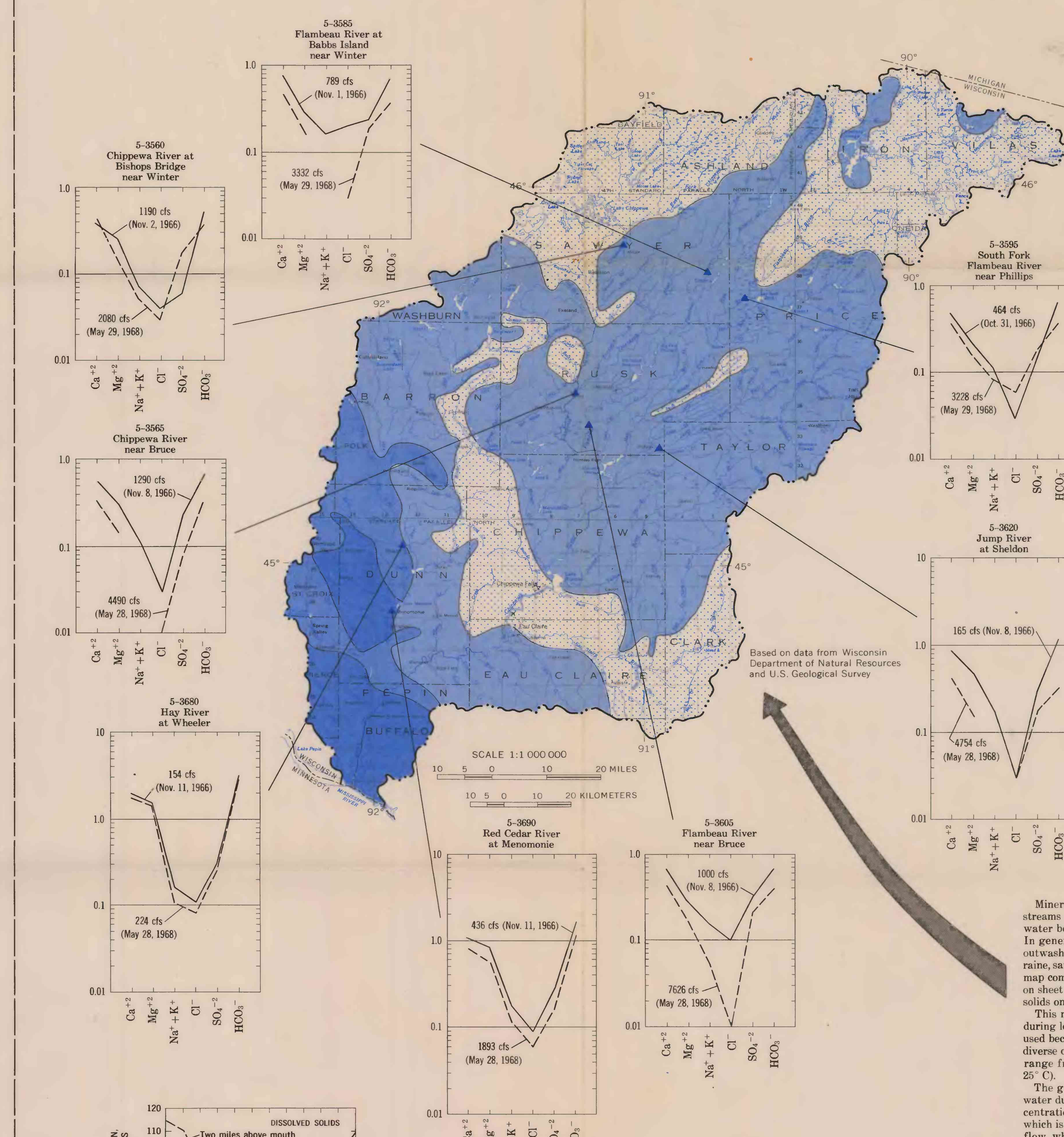
Low-flow discharge depends upon basin characteristics such as soil types, rock units, and topography (see "Distribution of Low-Flow Runoff", sheet 2). In small basins these characteristics tend to be uniform and produce distinctive low flows. Large basins, however, integrate the effects of many small basins and low flows of large basins are more directly related to basin size.

The low-flow recurrence of the Eau Galle River is very constant for long intervals of time, indicating that flow will be maintained during drought periods. In contrast the low-flow recurrence of the Yellow River is variable, indicating that flow will decrease considerably during periods of drought.

SURFACE—WATER QUALITY

The chemical quality of water in streams and lakes in the Chippewa River basin is generally very good. The water is characteristically soft, except in the southwestern part of the basin where it is hard because of the dolomitic rocks and calcareous glacial drift. Total mineralization of streamflow is low in the basin and is lowest during high streamflow in April, May, and June.

Wisconsin has set high standards of surface-water quality, and its Department of Natural Resources conducts an active program of pollution detection and abatement. The Department's last inventory of pollution sources in the basin (Schraufnagel and others, 1964a and b) showed that pollution occurred below many municipalities and industries, especially on the main stems of the streams. Most of this pollution is in the lower part of the basin and is concentrated in short reaches below points of waste disposal. Most stream reaches in the Chippewa River basin are relatively unpolluted. A restudy of the Chippewa River basin was underway by the Department in 1969.



EXPLANATION

Specific conductance, in micromhos at 25° C, of surface water during low-flow conditions	Approximate dissolved solids, in milligrams per liter, derived by empirical relationship from conductance
0–100	0–65
101–250	66–162
251–400	163–260
401–600	261–390

Gaging station
Surface-water divide

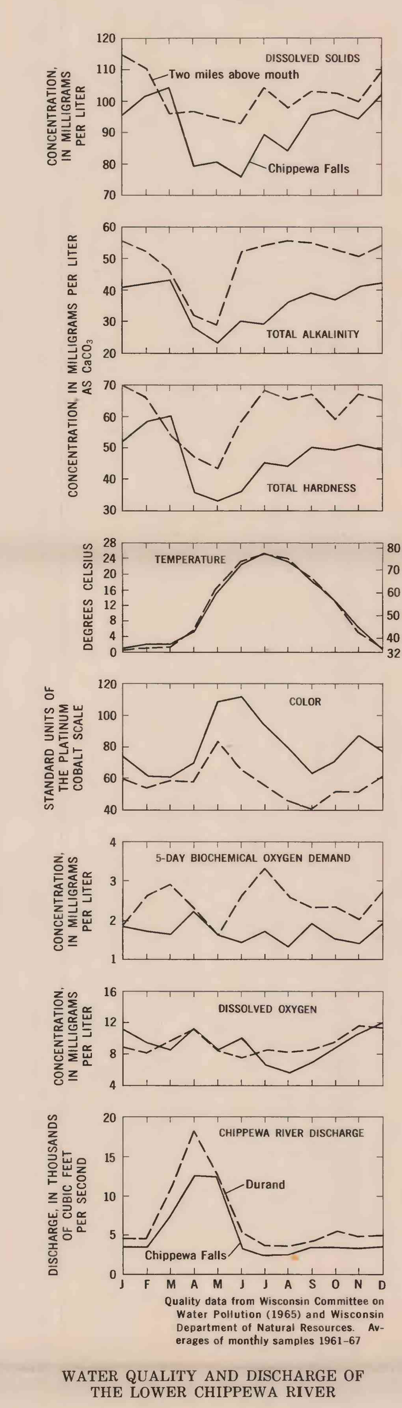
Chemical quality
Solid line indicates sample taken during low to average flow; dashed line indicates sample taken during moderately high flow. Analyses by U.S. Geological Survey

SPECIFIC CONDUCTANCE AND CHEMICAL QUALITY OF RIVERS

Mineralization, as indicated by specific conductance, of water in streams during low flow is directly related to mineralization of ground water because low flow is composed mainly of ground-water runoff. In general the specific conductance in streams is lowest in areas of outwash, and successively higher in areas of end moraine, ground moraine, sandstone, and dolomite. The distribution pattern shown on the map compares closely with these units as shown on the geologic maps on sheet 1, and with the patterns on the map of ground-water dissolved solids on sheet 2.

This map represents the specific conductance of water in streams during low-flow conditions. Data for the main stem streams are not used because they represent mixed flow from large drainage areas of diverse characteristics. In the Chippewa basin, dissolved solids (mg/l) range from 60 to 70 percent of specific conductance (micromhos at 25° C).

The graphs around the map show the chemical quality of surface water during two different stages of flow at 8 gaging stations. Concentrations of ions are generally higher during low-to-average flow, which is mainly from ground water, than during higher-than-average flow, which is mainly from surface runoff. The dominant ions are Ca^{+2}, Mg^{+2}, and HCO_3^-. The concentration of Na^+, K^+, and Cl^- ions, generally very low, tend to decrease with an increase in discharge.



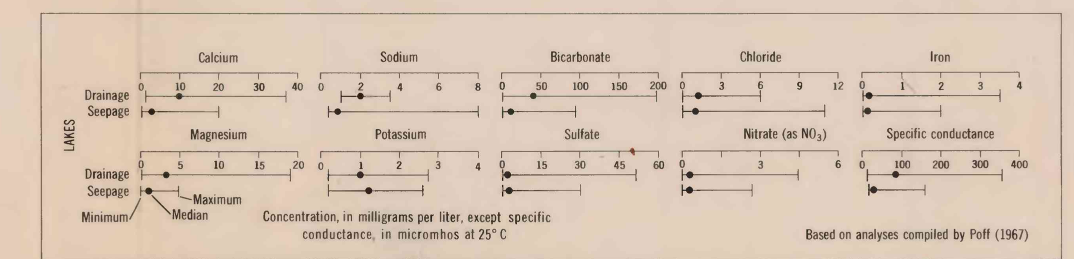
WATER QUALITY AND DISCHARGE OF
THE LOWER CHIPPEWA RIVER

Quality of water in the Chippewa River changes with discharge and with season. At the river mouth dissolved solids, alkalinity, and hardness vary inversely with discharge because they have a relatively constant input from ground-water discharge that is diluted periodically by overland runoff. Highest concentrations occur during winter low-flow conditions. These relations are altered somewhat at Chippewa Falls, probably due to mixing and storage of water in the reservoir.

Water temperature follows the natural seasonal pattern of air temperature and has a wide range.

Color of the water is due mainly to organic matter from decomposed vegetal matter in swamps. This matter collects during winter and other low-flow periods because water movement is slow, and it is flushed out of the swamps by large increases in flow. The major rise in color concentrations, therefore, occurs in the spring after the snowmelt runoff has moved the coloring matter into the streams. The color is much lower at the river mouth because of greater dilution by ground-water and by the Red Cedar and other streams in the southern part of the Chippewa basin which drain few swamps.

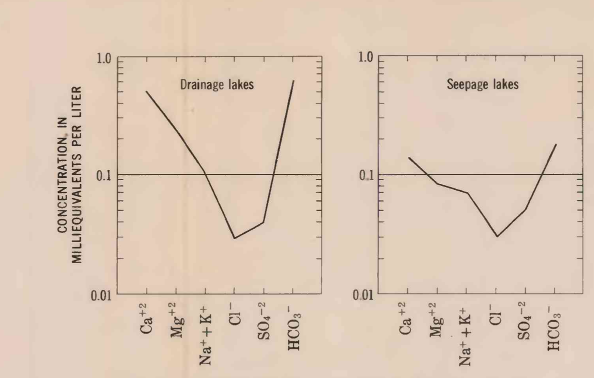
BOD (biochemical oxygen demand) is low and DO (dissolved oxygen) generally is above the minimum 4 mg/l required to support warm-water game fish. BOD is somewhat higher at the river mouth than at Chippewa Falls because the sampling site at Chippewa Falls is above waste discharge points at Chippewa Falls, Durand, Eau Claire, and Menomonie.



QUALITY OF LAKE WATER

Lakes in the basin have low concentrations of chemical constituents; however, seepage and drainage lakes have different characteristics. Drainage lakes have much higher concentrations of calcium, magnesium, sodium, and bicarbonate than seepage lakes, but they have similar concentrations of other constituents. The water quality of drainage lakes, as shown by median concentration of chemical constituents, is similar to the quality of water in streams during high flow.

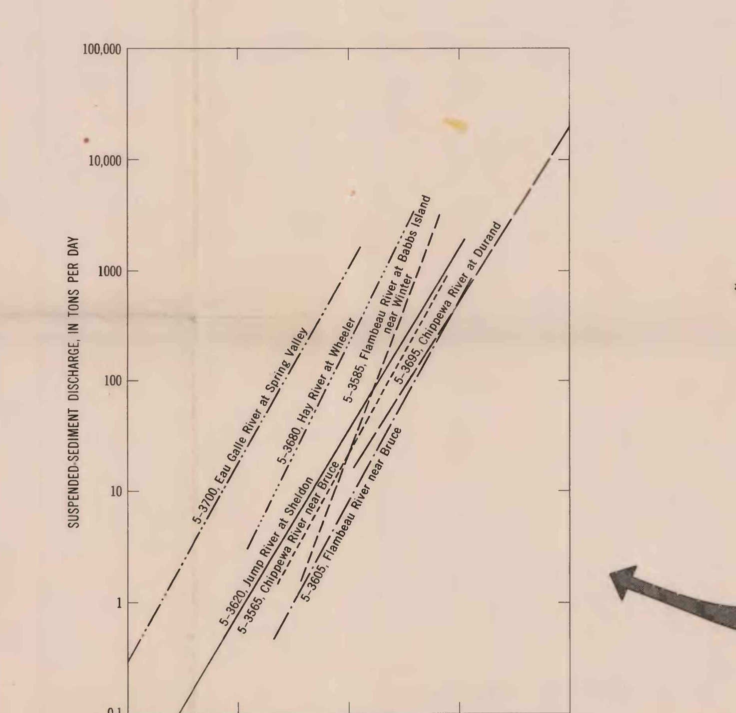
Lakes with hard water produce higher yields of fish than lakes with soft water (Moyle, 1949, p. 324). Thus, fish productivity generally is higher in drainage lakes than in seepage lakes.



MEDIAN CONCENTRATION OF IONS IN LAKE WATER

ESTIMATED AVERAGE ANNUAL SEDIMENT YIELDS

Station	Yields (1945–1967) Tons per square mile	Yields (1945–1967) Acre-feet
5-3605 Flambeau River near Bruce	6.3	6.95
5-3565 Chippewa River near Bruce	11	10.4
5-3585 Flambeau River at Babbs Island near Winter	12	7.00
5-3620 Jump River at Sheldon	12	4.01
5-3695 Chippewa River at Durand	18	94.7
5-3700 Eau Galle River at Spring Valley	29	1.09
5-3680 Hay River at Wheeler	40	9.92



WATER-SEDIMENT-DISCHARGE RELATION

Sediment carried by streams is not a major water-resource problem in the Chippewa River basin because erosion is very minor and quantities of sediment are small. Average annual sediment yields in the basin range from less than 10 to more than 40 tons per square mile. Soil types (and parent glacial deposits), land cover, land use, and topography greatly influence the sediment-yield characteristics. Natural and artificial stream controls also affect sediment yields.

The water-sediment-discharge curve for a stream represents the sediment-yield characteristics of the drainage basin. The lowest sediment yields are in the northern part of the basin where sandy soils, heavy forest cover, and low topographic relief predominate. The highest yields are from the southern part of the basin where slopes are steep, land is cleared for agriculture, and silty soils and loess deposits provide much sediment. For example, the Eau Galle River yields higher sediment loads, with less water discharge, than other streams.

These curves were developed by Hindall and Flint (1970) to estimate the average annual sediment-yield data in the table. The 1963–67 yields were extended to the base period 1945–67 by utilizing mean annual stream discharges.

Base from U.S. Geological Survey
1:500 000, 1968

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1972—W70138

WATER RESOURCES OF WISCONSIN—CHIPPEWA RIVER BASIN

By
H. L. Young and S. M. Hindall

1972